REMARKS

Original Claims 1-67 were pending in the subject application, including independent Claims 1, 12, 18, 24, 28, 43, 49 and 60. After entry of the amendment set forth above, Claims 1-67, including independent Claims 1, 11, 12, 18, 21, 24, 26, 28, 42, 43, 49, 52 and 60, are pending.

The Examiner indicated that claims 11, 21, 42 and 52 would be allowable if amended to correct any noted grounds for rejection under 35 USC 112, and if properly rewritten in independent form. This has accordingly been done, resulting in the addition of four new independent claims.

Drawings

In a "Drawings" section of the current Office Action, the Examiner suggests that Figs. 1-2 should be designated --Prior Art--. FIGURE 1 is herein amended accordingly, but the Applicants respectfully decline to label FIGURE 2 as prior art The figure suggests a flexible architecture, which, for example, permits a single "fly" capacitor to provide charge to an essentially unlimited number of distinct outputs, and contains material that is not known to be in the prior art. The architecture is "basic" only in that it omits switching details.

Specification

In a "Specification" section of the current Office Action, the Examiner suggests several useful corrections, clearly reflecting a particularly thorough review of the specification, which is greatly appreciated. The specification is amended herein accordingly.

Support for Amendments to the Claims

No new matter is added by the current amendments. Many of the amendments involve simple corrections or enhancements of clarity, and are fully supported by the claims as originally filed.

Support for other amendments follows. Amendments to Claim 1 regarding a maximum three-driver ring oscillator are supported, for example, by FIGURE 5 and the text associated therewith. Claim 40 has similar amendments as Claim 1. Support for amendments to Claims 3-4 and 48-49 regarding coupling circuitry that does not increase the clock output voltage rate of change may be found, for example, in FIGURES 3 & 6 and the text associated therewith, which describe passive coupling with that property. To increase the rates of voltage change (the slope) of the clock output would probably require active amplification. Support for the charge pump being in a monolithic integrated circuit is provided, for example, in paragraph 5 on page 2, and paragraph 45 on page 11, as required in Claims 12, 18, 24 28, 49 and 60.

Amendments to the Drawings:

Figure 1 has been amended in response to the Examiner's objections thereto by addition of the term "Prior Art" as requested. A replacement first drawing sheet incorporating these changes, together with an annotated first drawing sheet showing changes in red, are attached to this response as an appendix.

Attachments: Replacement Drawing Sheet

Annotated Sheet showing changes

Support for an absence of substantial transfer capacitor current, or for isolation of the control node, is provided, for example, by FIGURES 3 and 6 (as opposed to FIGURE 7), and the text associated therewith. Related limitations have been incorporated into Claims 7-8, 12, 24 and 60. Support for the output waveshape limitation incorporated in Claims 12, 20 and 28 may be found in paragraph 50 on page 12. Capacitive coupling limitations added to Claims 46 and 47 are supported, for example, by Claim 60 as originally filed, and by FIGURE 6 and the associated text.

Claim Objections

In a "Claim Objections" section of the current Office Action, the Examiner objects to Claims 2 and 10 as failing to further limit the claim from which they depend. Each objected claim has been amended to resolve the basis for such objection.

Rejections Under 35 USC 112

In a "Claim Rejections - 35 USC § 112" section of the current Office Action, the Examiner rejects Claims 3-9, 12-27, 31-32, 34-39, 41-42, 46-47, 52, 56, and 60-67 as indefinite.

The Examiner's thoroughness in reviewing the application is greatly appreciated. Each grounds set forth by the Examiner has been carefully considered, and responsive amendments entered. However, in view of the large number of such amendments, discussion of these amendments with respect to each individual claim has been omitted. The clarity will be apparent from receiving the claims as amended.

<u>Rejections under 35 USC § 102 and § 103</u>

The Examiner rejects Claims 1-2, 10 and 18, as previously presented, as anticipated by Tasdighi (US Patent 5,734,291), and Claim 19 as obvious over Tasdighi. He also rejects Claims 3-9, 19-20 and 22, and Claims 12, 14-17, 14-41, 43-45, 53-61 and 66-67, as previously presented, as obvious over Tasdighi in view of Hara (US Patent 5,446,418). The Examiner alternatively rejects Claims 3-9, 19-20 and 22-23, and Claims 12-17, 24-41, 45-51; 53-61 and 66-67, as previously presented, as obvious over Tasdighi in view of Ito (US Patent 6,617,933).

The claims are substantially amended hereby to more clearly define Applicants' invention over the prior art. An information disclosure statement is being submitted concurrently with this response. The uncovered art is obtained from a recent informal search of charge pump prior art. The listed prior art is not

believed to be more relevant than that cited by the Examiner, but is submitted out of caution in view of the impracticality of ensuring that no highly relevant teaching has been overlooked.

The remarks set forth below support a conclusion that each claim, as presently amended, is properly allowable over the prior art cited by the Examiner.

Not All Oscillators Would Conventionally Be Used for Driving Charge Pumps

A preliminary issue is addressed in regard to the teaching of Tasdighi with respect to charge pump clocks. Tasdighi is interested only in slowing the clock down during periods of light load, and he has minimal interest in how the oscillator is constructed. Tasdighi notes (col. 3 lls. 15-18) that oscillator 24 of Figure 2 "produces a train of pulses ... ." Then in regard to oscillator 14 of Figure 5, he notes as follows (col. 4 lls. 37-41, underlining added for emphasis):

> Oscillator 14 may use <u>conventional techniques</u> to generate a oscillating frequency across terminals 66 and 67. <u>One skilled in the art would understand</u> the numerous varieties of oscillators which may be used in this invention.

Thus, not only does Tasdighi explicitly teach the use of "conventional techniques," he further asserts that the skilled person would already know the varieties of oscillators that could be used with the invention. In view of this strong suggestion that only that which is already known (about oscillators for charge pumps) is taught, it would be improper to construe Tasdighi as providing a suggestion to extend the state of the art of oscillators in charge pumps. A variety of different oscillators were known to be useful with charge pumps, and it is to this variety of oscillators that Tasdighi refers.

In view of the foregoing, the statement by Tasdighi (col. 5 lls. 21-24) that "Oscillator 14 could be a ring oscillator or any other known form of oscillator" cannot fairly be construed as providing a suggestion for novel combinations of oscillators with charge pump circuits. Such a general reference to a broad category of devices cannot properly be interpreted as suggesting that oscillators not previously recognized as suitable for the purpose should be incorporated into charge pumps. There is a huge body of oscillator art, including, for example, RF carrier generators, and FM modulators such as the Ito reference. However, the types of oscillators which the person skilled in the art of charge pumps would expect to use in conjunction with a charge pump is much more circumscribed.

In view of the disclaimer to "conventional" and "known" oscillators, and in view of the vague and sketchy information provided about appropriate oscillators, it would be improper to argue that Tasdighi "fairly

suggests" the marriage of unexpected oscillators with charge pumps. It is respectfully submitted that Tasdighi as a whole, including the portions quoted above, does not, in fact, add to the state of the prior art in regard to oscillators used with charge pumps.

Hara primarily addresses clock circuits for charge pumps, with little attention given to the charge pump itself. Hara provides an example of a current-starved ring oscillator in conjunction with a charge pump. Hara is concerned with changing the operating frequency of the charge pump clock, in order to reduce the switching rate, and consequentially the power consumption, at light loads. In view of this focus, prior art techniques for changing frequency are relevant. However, Hara notes that the prior art oscillators are not necessarily relevant for charge pump applications. First, for example, Hara notes (col. 2 lls. 54-56, see also nearby text) that "Transistors 12p and 12n for current limiting shown in FIG. 19 [prior art] are applied only for a PLL circuit device and used only for serially controlling the oscillation cycle." The implication is that the PLL circuit of FIG. 19 is not suitable for charge pump applications, such as that of Hara.

This implication is buttressed by the following observations. FIG. 19 of Hara shows a ring oscillator with five inverting driver stages that can be switched so that feedback is provided around only three of them, and Hara acknowledges that ring oscillators of as few as three stages are known (e.g., col. 1 lls. 24-26). However, for his charge pump purposes (as opposed to oscillators for PLLs), Hara specifies that a ring oscillator should have five or more inverting driver stages (col. 5, lls. 60-62).

This distinction between oscillators generally, and oscillators for charge pumps, must be emphasized. In the knowledge of the Applicants, all oscillators incorporated in (at least integrated circuit) charge pumps have produced substantially rectangular output waveforms. This has been thought necessary to control timing so as to avoid simultaneous conduction, to reduce switching power losses, and to provide maximum conduction time for charge transfer.

Oscillators Previously Thought Unsuitable Unexpectedly Solve Problem

The Applicants found that the conventional wisdom resulted in charge pumps that conveyed high frequency noise into adjacent circuits. Digital circuits are generally quite immune to such noise, and thus this problem has not often been addressed. However, Applicants' charge pump is sometimes incorporated into an antenna switch, such as in a cellular telephone. Unintended noise generated by the charge pump can cause the switch to generate noise that is coupled to the antenna, resulting in a product that fails to meet stringent spurious emissions limits. The Applicants therefore needed to reduce noise from the charge pump.

After exhaustive analysis, Applicants determined that conventional charge pump clocks create much of the noise problem. The Applicants therefore developed some unconventional circuitry. Noise generation by charge pumps is not an unknown problem, but is not believed to have been solved by means of all of the features that have been described by the Applicants, or by any of the combinations of features recited in any of the pending independent claims, as presently amended.

Admittedly, oscillators are widely known and used. They have not, however, all been used to drive charge pumps, and the skilled person (prior to the Applicants' solution to the noise problem) would not have been motivated to use clocks that are significantly different than those that have been previously used with charge pumps. Some oscillators, for example, produce a pure sine wave output, substantially devoid of frequency content that deviates from an operational frequency, and are therefore suitable for carrier generation for communication purposes. Sawtooth generators are also known, and neither of these oscillators would be considered by the skilled person to be suitable for use in an integrated circuit charge pump. As noted in Tasdighi, the skilled person would understand which oscillators that would be used with charge pumps. Conversely, however, the skilled person would also understand that other types of oscillators are inappropriate for use to drive charge pump circuits. The assertions of Tasdighi, therefore, cannot extend the scope of oscillators that are considered suitable for use in a charge pump.

Thus, for example, three-stage ring oscillators are known, but they have not, to the Applicants' knowledge, been used to drive charge pumps. Applicants believe that these oscillators have not been used for this purpose because the output of a three-stage ring oscillator may become significantly sine-like in shape, which is generally considered undesirable in charge pump circuits. Instead, at least five, and typically more, inverting driver stages have been used in ring oscillators serving as clocks for charge pumps. Applicants determined that oscillators previously considered unsuitable for charge pumps are, to the contrary, not only suitable, but in fact confer important and unexpected advantages -- in particular, advantages of reducing noise injection into surrounding circuits.

Patentability of Individual Claims As Amended

Claims 11, 21, 42 and 52 have been found by the Examiner to require a combination of elements that is properly allowable over the prior art. Accordingly, each of these claims has been clarified as necessary and rewritten in independent form, and should thus remain allowable.

Claim 1, as presently amended, recites in part "a charge pump clock generating circuit including a ring oscillator comprising an odd number of not more than three inverting driver sections cascaded sequentially." As noted in the general remarks set forth above, three-stage ring oscillators have been considered unsuited for driving charge pumps. As also noted above, Tasdighi specifically suggests that charge pump clocks produce a "train of pulses," which describes a rectangular-shaped waveform. The problem with a three-stage ring oscillator is that the period of each half-cycle is only three times the rise (or fall) delay of a single stage. Thus, a three-stage ring oscillator will generate a waveform that has been thought too "un-square" to function as a suitable charge pump clock signal.

Claim 1, as presently amended, is properly allowable over Tasdighi at least for reasons that are set forth above, in detail, in the general remarks set forth above. A brief summary of those reasons, omitting details, is set forth here. First, Tasdighi makes no teaching or suggestion about the number of stages in a ring oscillator for a charge pump. Second, Hara explicitly teaches that ring oscillators should have five or more stages for use in charge pumps. Thus, Claim 1, as presently amended, is nonobvious even over the combination of Tasdighi and Hara. Third, Ito would not be combined with Tasdighi. It is respectfully submitted that the skilled person would not presume to incorporate, into a charge pump circuit, ring oscillators that are suitable for other purposes, such as for the phase locked loops (PLLs) in Ito, unless such use was previously known to be suitable for charge pumps by those skilled in the charge pump field. Fourth, Hara expresses that the three-stage ring oscillators of certain PLLs would not be suitable for a charge pump. Limitation to not more than three stages in a ring oscillator, for a charge pump, is thus nonobvious over the cited prior art, whether taken separately or in combination.

Claims 2-10 incorporate all of the limitations of Claim 1 by virtue of depending therefrom, and accordingly are therefore also properly nonobvious over Tasdighi, even in view of Hara.

Independent method Claim 43 incorporates limitations generally similar to those of Claim 1, and is properly allowable over the cited prior art for reasons substantially similar to those set forth above with respect to Claim 1. Claims 44-48 properly depend from Claim 43, and are therefore also properly allowable.

Claim 12, as presently amended, recites in part: "a charge pump clock generating circuit including an active driver circuit configured to both source current to and sink current from the charge pump clock output to cause a voltage waveform of the charge pump clock output to be substantially sine-like." As noted in the remarks above, Tasdighi explicitly states that charge pump clocks provide a "train of pulses." The skilled

person will well understand that a "train of pulses" does not suggest a "substantially sine-like" output, as required by Claim 12 as presently amended. For at least this reason, Claim 12 is nonobvious over Tasdighi.

Hara also fails to teach or suggest that a clock output to a charge pump should have a "substantially sine-like" output waveform. Indeed, Hara makes the point that ring oscillators with a small number of stages (three) may be suitable for other purposes, such as PLLs, but that a ring oscillator for a charge pump should have at least five stages. With more stages, the output will be more like a rectangular waveform, rather than substantially sine-like. Thus, Hara supports a contention that a substantially sine-like clock is nonobvious for use with charge pumps, particularly those comprised within a monolithic integrated circuit. Because Hara fails to teach all of the limitations of Claim 12 that are missing from Tasdighi, the combination of Hara and Tasdighi does not support a *prima facie* case of obviousness. Claim 12 is thus nonobvious over the combination of Hara and Tasdighi.

Ito describes oscillators for PLLs or VCOs. According to the reasoning set forth in the remarks above, a skilled person seeking an oscillator for a charge pump circuit would not be inclined to choose just any oscillator. It is respectfully submitted that the skilled person, prior to Applicants' invention, would not use a highly filtered oscillator (*e.g.*, as shown in FIGs 4 and 5 of Ito) to drive a charge pump. Ito is not concerned with conveying charge from an input to an output, as must be done with a charge pump. Ito teaches oscillators that would not be used by charge pump designers, at least prior to Applicants' teachings. Ito would not properly be combined with charge pump prior art, such as taught by Tasdighi. As such, features of Ito would not obviously be combined with features of Tasdighi and/or Hara to render obvious the invention claimed, for example, in Claim 12 as presently amended.

Thus, Claim 12 (as presently amended) is properly allowable over the references of Tasdighi, Hara and Ito. Claims 13-17 depend from Claim 12, and are thus also nonobvious over these references, at least by virtue of dependency.

Independent method Claim 28, as presently amended, requires features generally similar to those required by Claim 12, and is accordingly nonobvious and properly allowable over the cited prior art for reasons similar to those set forth above with respect to Claim 12. Claims 29-41 properly depend from Claim 28, and are therefore allowable as nonobvious over the cited art for at least the same reasons.

Claim 18 is presently amended to avoid possible confusion with prior art that couples the charge pump clock output directly to a Transfer Capacitor. In such prior art, the charge pump clock output itself

conveys or conducts charge directly between the source supply and the Transfer Capacitor, or possibly between the Transfer Capacitor and the output supply. Some of the charging or discharging switches in such circuits are passive, and may for example be diode-connected FETs in which the gate (control node) is connected directly to the drain. Thus, it might appear that the charge pump clock output in such circuits is capacitively coupled to the control node. The possibility of such confusion is addressed differently in various claims. In one case, the charge pump clock is required not to convey substantial charge to the Transfer Capacitor, while in another case the control node is required to be substantially isolated from the conduction path of the switch. As may be seen, those amendments do not respond to rejections by the Examiner.

Claim 18, as presently amended, recites in part (underlining added for emphasis):

> a charge pump clock generating circuit configured to provide a single-phase charge pump clock output coupled passively, without conveying substantial transfer current, to control nodes of each of the source switching devices to cause conduction during charge periods and nonconduction during discharge periods for all of the source switching devices, the charge pump clock output further coupled passively, without conveying substantial transfer current, to control nodes of each of the output switching devices

In the current Office Action, between pages 9 and 11, the Examiner rejects Claim 18 (as previously presented) as anticipated by Tasdighi. However, Tasdighi describes coupling an oscillator to the switches in only the most general of terms. No details of construction are given. Because the switches operate at significantly different voltage potentials, it is most likely that active level-shifting circuitry would be employed to couple the oscillator output to the switches. The lack of detail in Tasdighi does not permit a conclusion as to how the signal is coupled. In particular, the absence of detail cannot be fairly assumed to imply that Tasdighi provides a single-phase clock coupled passively to the switches, as required in Claim 18 as presently amended. A brief investigation of prior art also fails to reveal such a configuration (see, for example, the prior art submitted in the Information Disclosure Statement that is being filed concurrently with this response). Because passive coupling of a single-phase clock to the charge pump switches seems inconsistent with ordinary integrated circuit fabrication techniques, the simple block diagram provided by Tasdighi cannot properly be construed as fairly suggesting such a configuration. Accordingly, it is respectfully submitted that the requirements set forth in Claim 18, especially those quoted above, are nonobvious over Tasdighi.

Neither Hara nor Ito provides any information in regard to coupling the clock output to the charge pump switches, and thus cannot remedy the failings of Tasdighi in this regard. As such, Claim 18 is nonobvious over Tasdighi, even in view of Hara and Ito.

Claims 19-20 and 22-23, as presently amended, properly depend from Claim 18, and are consequently nonobvious over Tasdighi at least by virtue of such dependency. Independent method Claim 49, as presently amended, includes limitations similar to those remarked upon above with respect to Claim 18. Accordingly, Claim 49, as presently amended, is properly allowable over Tasdighi (even in view of Hara and/or Ito) for similar reasons as set forth above with respect to Claim 18. Claims 50-51 and 53-59, as presently amended, properly depend from Claim 49, and are properly allowable over the cited prior art at least by virtue of such dependency.

Independent Claim 24 is presently amended, in part, for reasons similar to those described above with respect to Claim 18, to avoid possible confusion with charge pump circuits in which the clock output actually couples the current to the Transfer Capacitor.

Claim 24, as presently amended, requires that the circuit be incorporated within a monolithic integrated circuit, and also recites in part: "d) a capacitive coupling circuit coupling a charge pump clock output to one of the control nodes corresponding to a source switching device or to an output switching device." In regard to capacitive coupling circuits, the Examiner states "Although neither reference clearly shows capacitive coupling circuit(s) to at least one transfer capacitor coupling switch, Fig. 20 of Hara shows capacitive coupling circuits (not labeled) connected to transistors 12p and 12n, which one of ordinary skill in the art would understand are types of coupling switches." With all due respect, Fig. 20 of Hara does not show the output of an oscillator, much less the output of a charge pump clock generator, connected to coupling capacitors. Rather, Fig. 20 of Hara is part of an oscillator for FM-modulating an analog input signal (paragraph bridging cols. 2-3). The oscillator is one that would probably not be used with a charge pump, having been developed for an entirely different purpose. In any event, the capacitors are not connected to the output of the oscillator (which would correspond to the charge pump clock output if it were used with a charge pump), but to the current-limiting circuits that are used to control the oscillation frequency of the ring oscillator. Thus, nowhere does Hara teach or suggest capacitive coupling of a clock output to a charge pump.

The Examiner acknowledged that capacitive coupling, as required by Claim 24 (both as previously presented, and as currently amended), is not seen elsewhere in the cited references. Similarly, such capacitive coupling is not found in any of the patents submitted in the IDS that is being filed concurrently with this

response. Accordingly, none of the cited references, even taken together, presents a *prima facie* case of obviousness for Claim 24. Claim 24, especially as presently amended, is therefore nonobvious over the cited prior art, whether taken alone or in combination.

Claims 25-27 properly depend from Claim 24, and are nonobvious at least due to such dependency. Independent method Claim 60 includes similar limitations, and is nonobvious for similar reasons as set forth above with respect to Claim 24. Claims 61-67, including Claims 62-65 that the Examiner noted as allowable, properly depend from Claim 60, and are also therefore nonobvious and properly allowable.

Conclusion

In view of the foregoing remarks and amendments, it is respectfully submitted that each claim, as presently pending in the subject application, is in condition for immediate allowance. As such, the Examiner is respectfully requested to withdraw each of his grounds for rejection, and in due course to issue a Notice of Allowance in respect of all pending claims.

Should the Examiner find any issue that can benefit from further clarification, he is respectfully urged to contact the undersigned by telephone. The undersigned will be pleased to do everything possible to reduce the time and effort required to complete a thorough examination of the subject application.

The Commissioner is authorized to construe this paper as including a petition to extend the period for response by the number of months necessary to make this paper timely filed. Fees or deficiencies required to cause the response to be complete and timely filed may be charged, and any overpayments should be credited, to our Deposit Account No. **50-0490**.

Respectfully submitted,

4/1/2005
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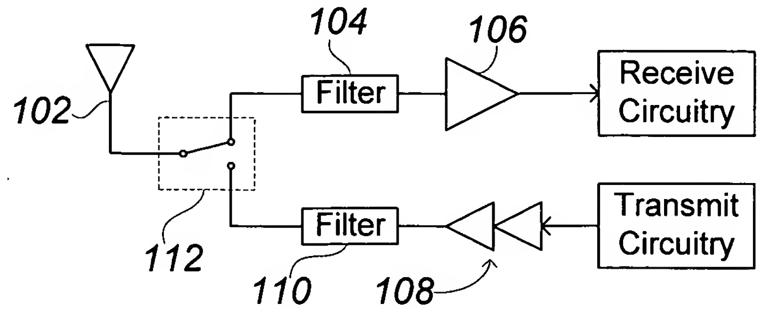

FIG. 1

(PRIOR ART)

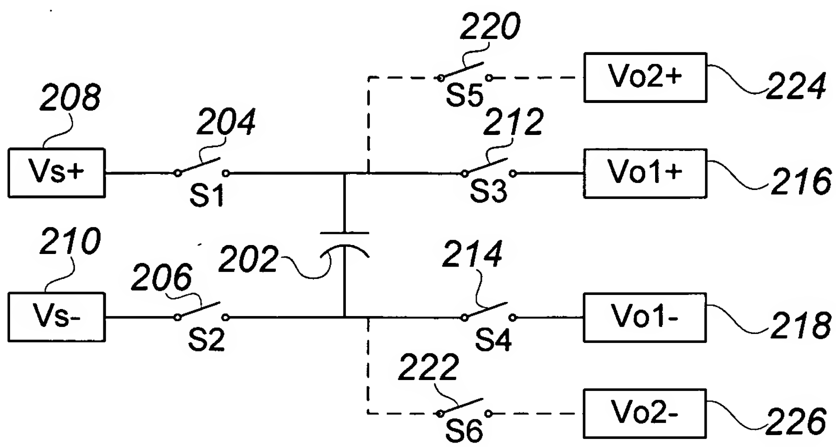

FIG. 2

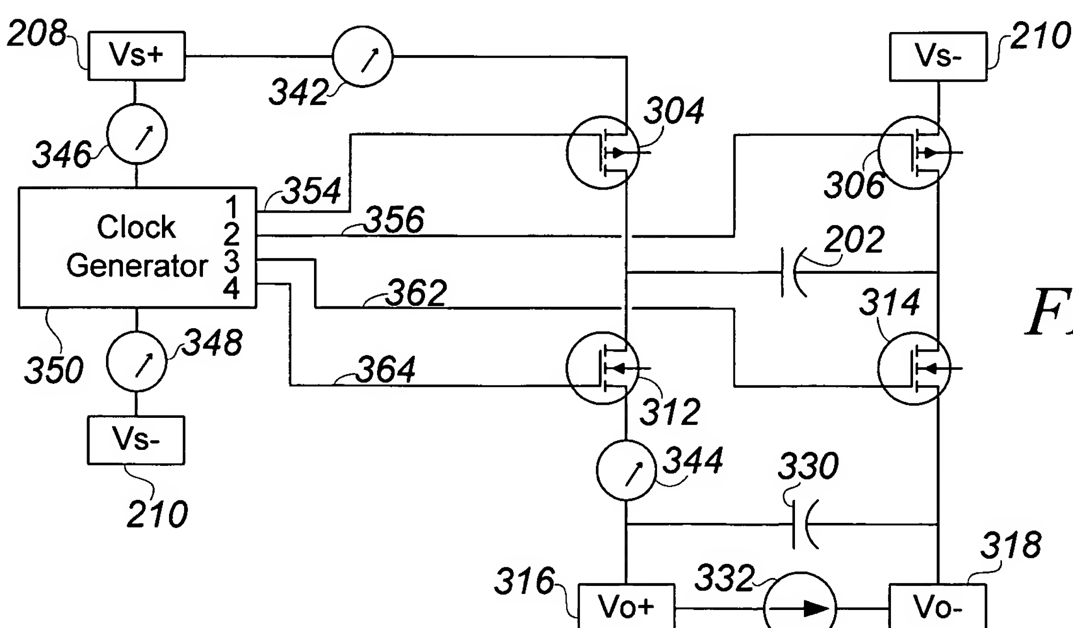

FIG. 3